Opportunities for Further Renewable Energy Utilization for Malaysia

Zubaidah Ismail
Civil Engineering Department, University of Malaya
Kuala Lumpur, Malaysia
zubaidahjka@gmail.com

***Abstract*-Fossil fuels had for so long been the most convenient and cheapest means of powering the world economy. They are now depleting fast and are also touted as not being eco-friendly. Natural gas once had the reputation of being a clean fuel is now considered not green. And with the new definition of what is and what is not green, nuclear power has suddenly taken centre-stage even among our Malaysian politicians. The objective of this paper is to explore the availability of alternative options and propose an option which is most suitable for the Malaysian industries. This study proposed that along with Biomass and Biofuels the Solar Option also be seriously considered as another long-term option.**

Keywords-alternative energy; assessment; green alternative; identification, viable option

I. INTRODUCTION

Nearly forty years ago the world was stunned with the First Oil Shock when the Arab members of OPEC decided to increase the price of crude oil from about USD3 per barrel to a hefty USD7 per barrel. Within a year the price rocketed to about USD12 per barrel. The spin-off from that shock was that suddenly consumers were designing and driving smaller cars with less petrol consumption. Suddenly marginal oil fields became economic, and investments were made on new sources of hydrocarbons and on new types of energy forms. Energy conservation, energy audits and more efficient systems became the buzz words of the day. Over the years the price steadily increased, steadied around the USD25 per barrel range for some time, steadily reduced down to a level of around USD12 per barrel, and steadily increased again to around USD30 per barrel. With about one price shock per decade we are seeing around the USD60 per barrel currently. The spin-offs of these shocks are still along similar lines. As long ago as about thirty years ago the crystal-ball gazers were already speculating on crude price of about USD100 per barrel. And we had broken that seemingly impossible ceiling not long ago.

It had been more than fifteen years ago that the Malaysian political leadership suggested that it was then timely to accelerate and make necessary preparations to bring those 'fringe' but unique domestic energy options into the mainstream. He was referring to the 'four-fuel strategy' of oil, gas, hydro and coal to include renewable energy as the fifth option. Now natural gas which was the cleanest of the clean has become a dirty thing and suddenly nuclear energy has become the darling most sought after. In 2002 the energy supply mix was roughly 48.9 % oil, 41.4% gas, 4.8% biomass and waste, 4.1% coal and 0.9% hydro. It was also targeted that renewable energy contribution was to reach 5% by the year 2005. Energy fuel production for 2002 was 80 million tonnes oil equivalent (Mtoe) with exports of 28 Mtoe. For 2003 oil and gas production increased by nearly 7%. For 2003 there was a change of strategy resulting in natural gas going down from 68.5% to 65.3%, coal increasing from 14.1% to 24.6%, fuel oil down from 10.1% to 3.5% and hydro decreasing by about 1%. In 2004 crude production was 750,000 bbl/d with 80,000 bbl/d of natural gas liquids.

Global population was about one billion in 1810, about six billion in 2004 and projected to be about nine billion in 2040. The energy and water consumptions also grow in tandem to this population growth pattern as pointed by Basiron [1]. The environment was showing signs of degradation and an inability to cope Darton [2]. Each time there was an oil price shock or each time OPEC decided to increase the price of crude oil we found consumers designing and operating more energy-efficient machines. Marginal oil fields become economic, and investments were made on new sources of hydrocarbons and on new energy alternatives, Ismail, Dawal and Karim [3]. Energy audits and projects for energy conservation and more efficient systems were implemented. Europe's citizens and companies need a secure supply of energy at affordable prices in order to maintain our standards of living. At the same time, the negative effects of energy use, particularly fossil fuels, on the environment must be reduced. That is why EU policy focuses on creating a competitive internal energy market offering quality service at low prices, on developing renewable energy sources, on reducing dependence on imported fuels, and on doing more with a lower consumption of energy EC:Energy [4]. Nearly ten years ago in 2003 the European Union agreed that by 2010, 21% of electricity consumed in Europe should be from alternative renewable resources and this had not been completely achieved. Several countries of the Union which were seen not to be keeping to the schedule had been given stern warnings, The Chemical Engineer [5]. Out of an estimated 29,000 MW of hydro-power potential available in Malaysia only about 2,000 MW has been exploited. There was a direct reference to solar as having a great potential as well, and that of biomass as another enormous source of renewable energy. Almost ten million tonnes of oil equivalent could be obtained from biomass coming from residues of the wood and agricultural sectors about 50% of which comes from oil palm industry waste. Fiscal incentives for renewable energy projects were given in the form of investment tax allowances and Small Renewable Energy Program (SREP) which encourages the selling of power to the National Grid. Twenty-eight biomass projects totaling a potential of 194 MW production and four

landfill-gas based projects producing a potential of 9 MW of power have been approved. There are eighteen mini-hydro projects producing a total of 70 MW which have also been approved. Resources bring wealth and waste; waste plus renewable energy may bring resources and waste heat. We will see the available so-called renewable energy resources such as solar, biomass, biofuels, wind, currents, waves and tidal, geothermal and nuclear, and assess those that are most practical and have the most potential for Malaysia.

II. MATERIALS AND METHODS

The traditional accepted components of an energy mix are taken as resources for the renewable energy industry. They are classified as biological or photosynthesis-based, products of direct radiation, actions resulting from gravitational forces, and others including geothermal, fuel cells and nuclear reaction. Availability of each for further exploitation in Malaysia is assessed.

In one way or other energy originates from the sun. Generally energy sources can be classified into the following types: those derived from the process of photosynthesis utilizing water and carbon dioxide in the presence of sunlight and chlorophyll to form sugars with further conversion to amino acids, starches, oils and other plant constituents which could also be taken up by animals and all these various forms undergo various extents of conversion and chemical and physical reactions and eventually appear in the form of biomass as direct fuel, cellulose which can be paralyzed to form alcohols, sugars and starches to be fermented also to alcohols which can be used as fuels, esterification of the oils to form bio-diesel, or cooked and fossilized over millions of years to appear as oil and gas. While the biomass, the alcohols and bio-diesels may be viewed as renewable through the propagation of the various energy crops which only take a few years, oil and gas and even coal are considered practically non-renewable. Another type of energy source is where the energy from the sunlight heats the land mass and the water mass of earth at different rates and creating local as well as global winds in the process. The winds blow over water and cause waves. The gravitational forces of the moon and the sun is yet another type of energy source that can be harnessed, and the last type of sources of energy may be looked at as those that mimic what happens in the nuclear reactor in the sky – the sun. The state of current and planned investments in RE by foreign as well as domestic investors was summarized by Hassan [6].

III. RESULTS AND DISCUSSION

A. Biological Sources

1) Biomass

Biomass energy is highly emphasized in the 9th Malaysian Plan. There are currently many incentives given to the promotion on the use of renewable energy from biomass in Malaysia. The biomass technologies ranged from the conversion of biomass into solid fuel such as briquettes and charcoal production to the direct combustion of biomass for use in the palm oil, rubber and brick making industries and the commercial use of biomass energy through the Small Renewable Energy Program.

Certain amount of biomass is converted into liquid fuel by pyrolytic process to manufacture bio oil. Part of this paper is allocated to the development of bio diesel in Malaysia. For gaseous fuel, some biomass is converted into biogas through fermentation and also through gasification Hoi and Koh [7].

Biomass and Biodiesel had been studied as a promising potential alternative for Malaysia, Sulaiman, Abdullah, Gerhauser and Shariff [8]. The utilization of oil palm waste is also discussed with its potential use as fertilizer, fuel and bio-oil, Australian Business Council for Sustainable Energy. Renewable energy in Asia: The Malaysia report. (August 2005). Energy in the form of electromagnetic radiation pours onto the earth heating the earth, creating weather and keeps everybody warm. All living things need energy to live, grow and reproduce. The energy from the sun is transformed into various forms of energy through various routes so that it can conveniently be utilized. Photosynthetic organisms remove about 100 x 1015 grams of carbon per year, World Renewable Energy Congress, (1999), but the photosynthetically reduced carbon is consumed by living organisms for their survival or by combustion such that there is more carbon dioxide released into the atmosphere than is taken up by photosynthesis. Burning of fossil fuels add on to the amount of carbon dioxide in the atmosphere. The oceans mitigate this increase by acting as a massive CO2 sink but it is estimated that the global CO2 concentration is increasing with time. Since CO2 is a known green-house gas it contributes to global warming which would lead to changes to rainfall patterns and the impact on plants and crops is uncertain. It is essential to appreciate the balance of life on earth with respect to the relationship of living organisms and the atmosphere. Several writers like Hall and Rao [9], Lawler [10], Cramer and Knaff [11] had discussed the subject of photosynthesis. Elaeis guineensis, the African oil palm, is the world's most productive energy crop. Not only does its fruit bunches yield vast amounts of oil that can be used to make biodiesel, a plantation also delivers ligno-cellulosic biomass that can be used as a feedstock for second generation ethanol, and the oil-production process yields copious amounts of residues that find use in biogas production, as a bioenergy feedstock for co-firing with coal or as base chemicals for the production of bioplastics and a series of highly valuable biomaterials. Fifty percent of biomass in Malaysia comes from the oil palm industry, while the rest comes from wood and other agricultural waste like rice straw and husk. In the past most of these waste material has been either used for heating or simply burnt and the ash recycled into the system. Since burning is no longer feasible two possible approaches towards the utilization of these wastes are direct use as fuel and conversion to alcohol and further used as fuel. This resource is cheaply available but it could be seasonal for some sources and collection and transport is a major problem. The palm oil industry utilizes a fair amount of this waste for its own energy requirements. JCN Network [12] reported on palm biomass power plants in Malaysia. There was also a power generation project with a capacity of 10 MW being implemented in Perlis utilizing rice husk and straws as fuel. Looking at the alcohol route, we see that the fermentation of cellulose to alcohol is not straight-forward and requires more research to make it viable. A Japanese company has now announced plans to use one such biomass stream in two biomass power plants in the eastern

province of Sabah, Malaysia. The plants operate on empty fruit bunches which, when disposed as waste, release methane, a global warming gas. Per ton of palm oil produced, about 1 ton of empty fruit bunches becomes available. The new biomass plants have an output of 10,000Kw each, which makes them rather small, but they are meant for local use, in an area that is not connected to the main grid.

2) Biofuels

Biofuels commonly come either from ethanol or the methyl ester. While Brazil has for a long time pursued the alcohol approach from the fermentation of sugar, the US has concentrated on the fermentation of corn. Malaysia have for the last twenty years or so been looking at the methyl ester route to palm diesel. These fuels burn cleaner with less emission, and combustion temperature is lower giving longer lasting engines as compared to petroleum. The octane rating is higher which means that the knocking tendency is less; and the flash point is also higher meaning that it is safer to handle. Experimental studies on the crude form of the oil had also been tested successfully in car engines. These fuels burn cleaner with less emission of green-house gases, and combustion temperature is also lower giving longer lasting engines as compared to petroleum-run engines. Prospects of coco biodiesel had also been investigated with promising results, Elumbaring-Rayat, Fabian and Agapay [13]. Alcohol is more miscible with water than gasoline thus minimizing separation problem in the storage tank; and less freezing problems. The challenge has for a long time been about the net amount of energy produced. Alcohol forms an azeotropic mixture with water meaning that there is a limit to the purity of alcohol you can get by simple distillation. Energy input into production was said to be high. There has been extensive debates Shapouri, Duffield and Graboski [14], Shapouri, Duffield and Wang [15] on the issue, and several recent work have focused on showing that there is in fact a definite net energy gain from the production. The other big challenge with both corn-based and palm-based biofuels is to change the perception of 'subsidized food burning'. Lane [16] reported that Malaysia was constructing nine pyrolysis biofuels plants by 2015; partnering with Ensyn, UOP. It will convert palm waste into 316 Mgy of gasoline, diesel and jet fuel. Ensyn and UOP's joint venture, Envergent, will provide the technical assistance to the project. The National Biofuel Policy was launched on 21 March 2006 under the Ministry of Plantation and Commodities. The Malaysian Biofuel Industry Act 2007 was enforced on 1 Nov 2008. With CPO price of RM 1422/mt, there is need for crude price to be more than USD 80/bbl for any price advantage to include up to five percent of biofuel in gasoline.

With declining palm oil prices from the latter half of 2008 to the first half of 2009, Malaysian bio-diesel plants found it profitable to restart or expand production for the export market. Malaysia takes the advantage to fill the gap caused by the EU's slap of duties on US-origin biodiesel or re-exports. The Government continues to put on hold the proposed mandatory blend of 5 percent of palm olein in diesel. In the near term, domestic consumption of biodiesel will be low and most all of the production will be exported, mainly to the European Union and United States.

In contrast to the rocketing crude palm oil (CPO) prices and subsidized retail petroleum diesel in the domestic market during the first seven months of 2008, the bio-diesel industry has to deal with depressed crude petroleum oil prices which make bio-diesel less competitive. The GOM continues to put on hold the proposed mandatory blend of 5 percent of palm methyl ester in diesel in the domestic market. For a start, the GOM has pledged that all government diesel-powered vehicles would start using biodiesel from February 2009.

Overseas markets remain attractive given the EU's vote in favor of sourcing 20 percent of its energy needs from renewable feedstock by 2020. Malaysian biodiesel exporters seek to fill some of the gap created by the implementation of CVD and AD duties by the EU on US-origin biodiesel or re-exports from the U.S. to the EU. For example, in late 2008, Carotech Bhd inked a US57 million contact with Swiss-based Trafigura Beheer BV, the world's third largest independent oil trader to supply 60,000 – 84,000 tons of biodiesel a year to Europe. Many other bio-diesel companies like Wilmar International which has one million tons of bio-diesel production capacity, are firing up their mothballed plants and all are eyeing the EU market.

However, the EU's concerns over negative impacts of oil palm cultivation on environment and land-use have raised fears of emerging barriers for palm methyl ester exports to the EU. A news report indicated that the German government has decided to defer the implementation and also to review the proposed law at the end of this year.

Opportunities for US exports of biofuel or a biofuel feedstock to Malaysia are limited as the country already has in oil palm a plentiful feedstock. Also, retail petroleum prices in Malaysia are subsidized, diminishing the economic viability of importing biofuels as an alternative fuel source.

Jatropha, a tough bush with oil bearing fruit has excellent small-scale potential but needs more research before it could be cultivated on a larger-scale area. The shrub grows on marginal and arid land and needs little care. Jatropha is non-edible, so avoiding the food vs fuel controversy. Although fund has been allocated to facilitate research and development of the crop, the GOM has yet to fully endorse the significance of jatropha. In early January 2009, Air New Zealand successfully conducted a test flights using a blend of 50;50 jatropha and Jet A1 fuel Cottrell and R. Hoh [17].

B. Direct Radlation

1) Wind

The wind characteristics and the power potential of West Malaysia are analyzed based on the wind data supplied by the Meteorological Department of Malaysia Lee [18]. The study is of interest in the utilization of wind power in West Malaysia and the surrounding islands. Malaysia is building Asia's first hybrid power plant that uses four different kinds of energy sources, including wind power, to cut generation costs by almost half, Bernama [19]. There are forty-three meteorological stations all over Malaysia recording weather conditions including wind histories. Wind has been utilized as a source of energy to propel ships and through windmills to do mechanical work. Wind power can also be used to turn wind

vanes for electricity generation. We have seen remote applications like telecommunications, rural residences, and water pumping; and a 'wind farm' could also be a source of centralized power supply, Sylvester [20]. The resource is renewable; it could be left unattended for long periods of time with low operating cost. However, wind is a low density source of power, capital expenditure is high, and it is unpredictable and not too reliable. The hybrid form is usually installed with additional generating system to achieve more flexibility and reliability. A fair amount of land is required and there is some negative visual impact. The different types of land materials and water on the earth's surface result in different amounts of heat being absorbed and consequently cause an uneven heating of the surface by the sun. During the day the air above the land heats up much faster than the air over water in the oceans and the seas. The warm air above the land expands and rises and the heavier cooler air rushes to take its place thus creating what we know as wind. At night the wind direction is reversed since the air cools more quickly over land than over water. The large atmospheric winds that circle the earth are created in a similar manner because the land mass near the equator is heated more by the sun than the land mass near the North and South Poles. People have been harnessing wind energy for thousands of years whenever they use sailing ships to travel, windmills to grind wheat and grains, pump water, cut wood at sawmills and generate electricity. Wind is a clean fuel and wind farms do not pollute the environment. The environmental drawbacks may be the negative effect on wild bird populations and the visual impact on the landscape which again is subjective.

Is it possible to harness the wind energy on a large-scale basis to generate electricity in Malaysia? Malaysia's mean annual wind speed is low at no more than 2 m/s. Nonetheless, the wind does not blow uniformly throughout Malaysia; wind speed varies according to region and month.

Malaysia experiences two main weather seasons: southwest monsoon (May/June to September) and northeast monsoon (November to March). Wind speeds during the southwest monsoon are often below 7 m/s, but during the northeast monsoon, wind speeds could reach up to 15 m/s particularly in the east coast of Peninsular Malaysia. Moreover, during April to September, the effects from typhoons striking neighboring countries (such as Philippines) may cause strong winds (even exceeding 10 m/s) to Sabah and Sarawak. So although Malaysia, as a whole, experiences low wind speeds, some areas in this country see strong winds during certain periods of the year.

Currently, it cost about RM1 for every 1 W of electricity generated from wind energy in Malaysia. Thus, to meet 10% of Malaysia's electricity demand in 2020 would cost approximately RM1.4 billion to setup the required number of windmills. These figures so far show it is plausible to harness the wind energy for electricity generation in Malaysia. Although the minimum wind speed required for windmills is between 3 to 5 m/s, the minimum wind speed for commercial viability is instead 7 m/s. None of the 15 towns I analyzed had mean monthly wind speeds exceeding even 5 m/s.

According to Tenaga Nasional, in collaboration with Argentina's renewable energy firm, Industrias Metalurgicas Pescarmona S A (Impsa), 500 to 2000 MW worth of electricity could be generated from wind energy in Malaysia (meeting between 3.5 to 14% of the expected demand in electricity by 2020). They further reported there are areas such as the Malaysian-Thailand border which see wind speeds up to 15 m/s Christopher Teh, 8 Nov 2010 [21]; Chong [22].

Malaysia is a country vastly surrounded by water. Wave power and offshore wind power has been recognized by the international community as a renewable clean energy source. Analysis was conducted for the potential of wave energy and wind energy along the coastline of Malaysia from the data obtained by the Malaysia Meteorological Service (MMS) from 1985 to 2000. The Malaysian coastline has been divided into four major zones, east peninsular Malaysia, west peninsular Malaysia, Sarawak and Sabah. The wind waves, swells and wind characteristics (maximum wind wave height / period / direction, average wind wave height / period; maximum swell height / period / direction, average swell height /period and vector resultant wind direction / speed) were analyzed. Locations situated in the South China Sea has the most promising site for wave power potential, with the highest energy resource available in the months of November to February, which coincide with northeast monsoon season. The annual wave power is below 5.0 kW/m. The offshore wind energy resource for this region also shows the same trend as the wave energy. The highest potential is in the east peninsular Malaysia with annual vector resultant wind speed of 4.1mls. Chiang, Zainal, Narayana, and Seetharamu [23].

2) Waves

The wave action pushes air in and out of a chamber turning turbines in the process, California Energy Commission [24]. It is renewable and the capital investment is reasonable and cheap to operate. There is no waste or pollution, it can generate a large amount of energy and there is no negative visual impact Its application to-date is still not widespread. Waves are created by the wind at it blows across the oceans and the seas. Waves are a powerful source of energy. The wave action can be directed to push air in and out of a chamber which turns turbines in the process. It is renewable and the capital investment is reasonable and it is cheap to operate. There is no waste or pollution, it can generate a large amount of energy and there is no negative visual impact. However, its application to-date is still not widespread. The challenge is to build and secure a structure sturdy enough to withstand the rough sea conditions and at the same time capable of generating enough power from small waves. On top of the need for a sturdy civil structure a suitable site with consistently strong waves has to be found. Furthermore, corrosion and marine growth could add to maintenance costs, and noise is also an environmental nuisance. Noise is also another nuisance. The future of wave power was also discussed by Ozcan [25].

3) Mini-Hydro

Muhibullah, Radzi and Hakim [26] reported that Perak was going to be the first state to own and operate a mini-hydropower plant followed by Sabah and Sarawak. Like in most other sources of energy, the principle is the use of kinetic energy of the medium to turn turbines which in turn enerate electricity. In this case the medium is water. Hydro power is

already included as one of the major energy options. The mini-hydros are those which are producing a few MWs only per unit. They serve the rural areas, and have low capital and operating costs. Solar energy input into surface water evaporates it to form clouds and gain potential energy. The rain hopefully falls into catchment areas and dammed-up collecting into a massive amount of potential energy after losing some through the falling rain. The potential energy is converted into kinetic energy through the water channels before hitting the turbine blades and converting it into mechanical energy. There are losses through the channel and in the conversion process. The energy is further converted to electrical energy through electromagnetism. Again there would be conversion losses. The power is stepped-up for transmission purposes and then stepped-down for suitable consumption. Again there would be step-up and step-down losses as well as heat energy losses through transmission. There would be further losses at the appliances because of heat and other inefficiencies in the conversion process. Hydro is not a major future energy option because the potential of harnessing gravity this way are either already being exploited or is unavailable because of environmental reasons. Although it produces no carbon dioxide and there are no emissions, the down-side, however, is that there need to be vast catchment areas which need to be flooded and this would have some direct negative impact on the environment.

Mini-hydro power plants, once an unpopular method of generating electricity, seems to emerge as a viable alternative now spiraling fuel cost, especially coal, has had a hard hitting impact on power producers. The importance of these plants have become more apparent now that Tenaga Nasional Bhd has started rehabilitating mini-hydro sites over the last few years as part of its green energy efforts. The move will not only help the utility giant reduce its power generation cost and carbon dioxide emission, but also create awareness for renewable energy and fast track the government's aim to move towards green energy.

By 2015, TNB aimed to produce 330 megawatts (mw) of power from biomass, followed by mini-hydro (290 mw), solid waste (200 mw), biogas (100 mw) and solar photovoltaic (65 mw). TNB has 36 mini-hydro plants but only 21 were operational, nationwide. The total capacity of the 36 mini-hydro plants is about nine mw, he said, adding that the remaining 15 mini hydro-plants were currently going through rehabilitation.

Mini-hydro plants, in most cases, do not require a dam or barrage to store water, instead water is captured from a waterfall through a weir which is then channeled through a 1.65 kilometer long pipeline which connects to the plant. Mini-hydro plants of such capacity require an investment of RM70 million. Another advantage of hydro plants is that power can be generated, as per demand, by managing the flow of river water, which means less wastage of energy.

4) Solar Energy

Malaysia is blessed with abundant sunshine. The Australian Business Council for Sustainable Energy [27] reported that solar radiation in Malaysia is high by world standards, Kevin [28]. Despite the abundance of solar energy resource in Malaysia, the utilization of this renewable energy has only been limited to the installation of about 10000 units of solar heaters, and photo-voltaic systems for rural electrification and minor applications involving telecommunication, street and garden lighting, and ticket dispensing machines. Photo-Voltaic Cells

Photo-Voltaic with about 15% conversion gives about one w/m2. There are some photo-voltaic systems for rural electrification in Sabah and Sarawak, and minor applications involving telecommunication, street and garden lighting, and ticket dispensing machines. There have been a few solar-powered cars competitions organized. The advantages of these systems are that the capital and the operating costs are fairly cheap; there is no pollution or the production of green-house gases and it could be modular. With the rapid expansion of the building construction industry the potential development in the application of the building integrated photo-voltaic technology is great. Research and development of such systems are greatly wanting. Commitment of the relevant authorities and organizations is greatly needed. The downside about solar radiation is that it is only readily available during sunny days. And during the winter months the hours of sunshine are very much shorter. The source is also not too efficient on rainy and cloudy days. There could also be some negative visual impact, and the maintenance of such systems could be costly. Thailand had gone into investing in solar power in a big way with Southeast Asia's Largest Solar Power Plant at 44MW, Suntech Power Holdings [29].

One of the main concerns is the need for a large track of land. Planting cost is about USD 4 mil/MW ~ 6 times more expensive than the open-cycle, 4 times higher than the combined- cycle and three times higher than a coal-fired plant. Although Malaysia is blessed with plenty sunshine but for the clouds and the lack of unproductive land are barriers to smooth operations. To fully realize the full long-term potential of solar energy the above obstacles have to be satisfactorily resolved. The target is to build 1.25 gigawatt of solar power by 2020, increasing RE to 5.5% in 2015 from the current 1% [30].

C. Gravitional Forces

1) Tides

Tides are caused by the gravitational pull of the moon and the sun on the oceans of the rotating earth. Tidal energy is harnessed by using barrages much like a dam, only that it is very much bigger but have a much lesser height. Either the flow could be used to turn turbines or it could be used to push air which in turn turns the turbine. The potential amount of power is enormous, but it is a big challenge to harness. It is renewable and predictable, have low operating cost, and have not muck negative visual impact. The environmental impact could, however, be far-reaching where the mud-flats and the ecosystem of the beach could be changed. The system only works when the tide is coming in or going out so alternative supply needs to be provided in between. Furthermore there are only very limited suitable sites around the world where the system could be installed Bernshtein, Wilson and Wong [31]. Agnew [32], Baddour [33] and Song and van Walsum [34] also discussed the potential of this alternative.

2) Currents

Chiang, Zainal, Narayana and Seetharamu [35] reminded

us that Malaysia is a country vastly surrounded by water. Wave power and offshore wind power had been recognized by the international community as a renewable clean energy source. In Malaysia, study on ocean based energy sources is still in the infant stage. Hence a study on the potential of wave and wind energy along the coastline of Malaysia has been taken up to estimate the available resource potential. Ocean currents occur naturally through narrow channels as a result of tidal action or due to temperature gradient. It is still in an early stage of development but areas in UK, Marine Current Turbines [36] and Rudkin and Loughnan [37], Ireland, Italy, Philippines, Japan, US, Canada and New Zealand, had been identified as suitable sites and had been developed California Energy Commission [38]. The regular and periodic raising and lowering surfaces create the strong tidal currents. The strength of tidal currents depends on location of the site on earth, shape of the coastline, and shape of the sea-bed. The principle is simply the use of kinetic energy of the moving water and converting it to rotational energy and electricity. Currents are predictable both in amount and timing and are not affected by weather conditions. The resource is renewable, have minimal environmental impact, have a high energy density as compared to wind which means more compact equipment, and the velocities are more predictable and less fluctuating giving rise to more accurate sizing of equipment, US Department of Energy [39]. Furthermore the land use is minimal, there is no negative visual impact, can be sited near high population areas, able to apply the modular concept and can avoid large civil engineering works. The challenges are in the technical areas of avoiding cavitation, minimizing marine growth and ingress of debris into the system. Capital outlay could also be substantial and maintenance could also be high due to possible seawater corrosion of equipment and parts. More research needs to be conducted in this area.

D. Other Approaches

1) Geothermal

The temperature at the centre of the earth is about 6000C. There is roughly an increase of 1C for every 36 meters down into the earth. In volcanic areas molten rocks could be close to the surface. By drilling a hole and pumping water onto the hot rocks, steam could be produced, purified and utilized to drive turbines for electricity generation, California Energy Commission [40]. Facilities could be found in Italy, New Zealand, Iceland, Japan, Philippines, and the US. In countries like Philippines, a high percentage of the energy mix comes from this resource. The technology does not cause pollution, does not produce carbon dioxide, the system is compact, and requires minimal operating cost However, the sites were limited, the rock structure and properties for drilling through must be suitable, and sometimes the facilities could lose their heating capability for some time. There could also be some negative visual impact from leaking steam, and poisonous gases could also be emitted. Electroconsult [41] were constructing geothermal power plants in Kamojang with a capacity of 50 MW, in Sarulla with 300 MW, Karaha Bodas and Darajat with 55 MW and Gunung Salak with 3 x 55 MW. The status of the industry in the Philippines, and the prospects in the whole territory of South Pacific Islands to convert geothermal energy for electricity production was undertaken by Ásmundsson [42].

In Malaysia this potential resource is very limited. Tenaga Nasional Bhd (TNB) has identified four potential geothermal power generation sites that could collectively generate more than 2MW of electricity in Peninsular Malaysia. In the early stages of a feasibility study conducted jointly by two units under TNB - Generation Asset Development (GAD) and TNB Research Sdn Bhd - these projects are expected to be fully implemented by 2016. The company had completed the first phase of a feasibility study on the prospects of generating geothermal power – another form of renewable energy – in the four undisclosed locations in the peninsula.

It had managed to secure a 20% confidence level for the projects. The group faced some challenges, especially in terms of rights and land ownership, to proceed with the geothermal power generation projects. TNB's proposed geothermal power plants use steam produced from hot water springs to generate electricity. There are more than 40 thermal springs in Peninsular Malaysia. Most of these springs are good potential sites to generate geothermal power as part of the nation's plan to enhance its renewable energy potential.

2) Nuclear

The Malaysian government had approved the construction of a nuclear power plant which was expected to start operation by 2021 to meet the country's power demand in the future.

Nuclear was once the Fifth Energy Option for Malaysia. It was a forgotten option for a long time, but it was one that still remained as the most important option. There is more energy potential in nuclear fuels than the combined total from oil, gas, coal and hydro. There were scatterings of nuclear power plants in India, Eastern Europe and Korea, but the main concentration of these plants are in US, Western Europe and in Japan. There was a need for the technologists in Malaysia to be in a state of readiness to embark on this option now that the green light was given; and a state of readiness was more than twenty years of research reactor experience with production of isotopes for the health and NDT industries, and the ability of making some gas centrifuge components had been questioned by some, Chan [43]. The star, of which our sun is one, relies on nuclear fusion for their output of heat, light and other radiations. If one believes in the Big Bang Theory, then the Earth may be considered as a fragment of the Sun. Fusion reaction is exactly what is happening on the Sun. Energy from fission reaction is derived from a nuclear reaction involving uranium or plutonium as the fuel which originally comes from the fragment of the Sun. Fission nuclear reactors were either the slow thermal kind using moderators or the fast breeder type using purer fuels and able to generate or 'breed' new fuel form which was useful in the context of renewability. There are, however, still fears of catastrophic accidents due to human and system errors. And this was made real by the catastrophic destruction of a number of nuclear power plants by earth-quakes in Japan recently.

3) Fuel Cells

Available types of fuel cells are the phosphoric acid, molten carbonate, hydrides and solid oxide types. A fuel cell

system running on hydrogen could be compact and light-weight and have no moving parts to maintain. An electrolyser/fuel cell system can store an indefinite quantity of hydrogen which then becomes suitable for long-term energy storage. Research in fuel-cell technology is currently limited to a few Universities and the Energy Center.

The Government's plan is to boost renewable sources in the country's power-generation mix from around 1%, or 41.5MW, currently to 5.5%, or 985MW, by 2015. The country is still highly dependent on fossil fuels – coal, natural gas and oil – as sources of electricity. Collectively, these depleting natural resources make up around 85% of the country's generation mix. Malaysia has great potential for renewable energy, sources of which include biomass and biogas, hydro and solar. There were challenges that the country faced in promoting renewable energy technology including the reliability of the technology, difficulty in integrating renewable energy into the main power grid as well as the high capital costs.

IV. CONCLUSIONS

Malaysia does not have much near-surface molten rock, so geothermal is not really an option. Out of the three ocean-related sources of waves, tides and currents, the one with some potential is perhaps wave energy off-shore the east coast. Malaysia has plenty of sunshine and plenty of wood and other agricultural waste. Investments in the research and development of these resources are logical and essential. It might also be worthwhile spending some time on wind energy potential, and definitely someone did not forget the nuclear option although it had not been accepted entirely. Ultimately all energy comes from the sun. The closer and more direct the technology gets to mimicking the Sun or what happens on the Sun the more efficient would be the process of converting the energy from the Sun. There would be fewer tendencies for losses due to conversion and operational process inefficiencies. The logical choice becomes obvious.

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